BY MARY ADAM THOMAS

THE WATER PETAL

Nourishing from Within

The following is an excerpt from the upcoming book, *Building in Bloom: The Making of the Center for Sustainable Landscapes at Phipps Conservatory and Botanical Gardens* by Mary Adam Thomas. The book offers a petal-by-petal overview of how Pittsburgh's Phipps Conservatory and Botanical Gardens pursued the Living Building Challenge for the "CSL," which will begin to measure its performance in pursuit of Challenge certification when it opens in fall 2012. This is an adaptation of the book's water petal chapter, which explores how the owner worked with the design and engineering team to customize a net-zero water solution for the project. For more information on Phipps Conservatory and the Center for Sustainable Landscapes, visit www.phipps.conservatory.org.

Summary of the Living Building Challenge Version 1.3 Water Petal

Petal Intent

The intent of this petal is to realign how people use water in the built environment, so that water is respected as a precious resource.

Petal Imperatives

Net Zero Water
Sustainable Water Discharge

TRICKLES OF CHANGE

The Water Petal is one of the Living Building Challenge's most profound. It reaches beyond the boundaries of a single project to effect change on a much broader scale. Net-zero water on an individual site is just the beginning; the petal is intended to realign the way water is used throughout the built environment.

Luckily for the Center for Sustainable Landscapes (CSL) team, Pittsburgh is in a water-rich region of the country. At the same time, the idea of reducing water demands on the campus of a conservatory that houses thousands of plants with enormous irrigation demands seemed a bit ironic at first. But the Challenge asked for the CSL to deliver net-zero water performance within its own perimeter at a minimum, regardless of the needs of Phipps Conservatory and Botanical Gardens' upper campus. Still, the project's philosophy was to look at whole systems and do whatever possible to connect seemingly distinct operations – whether between performance areas of the Challenge or between the two halves of the Phipps campus.

Meeting the Challenge for the CSL, therefore, meant designing an overall water-balanced approach, incorporating all three tiers of water that would need to enter and exit the building: potable water (suitable for drinking and hand-washing), greywater (storm and drain runoff) and blackwater (contaminated by human waste). Rather than look at any of these sources as an individual problem, the team explored comprehensive solutions that would yield net-zero total usage for the entire site and fit the appropriate quality of water with its intended use.

> "When you attach something to a larger building, you have waste energy, waste heat and waste water that you can grab. Every building is part of a campus or a complex or a neighborhood that can help make it an amazing performer. The CSL's neighborhood is Phipps Conservatory and Botanical Gardens. Most people don't think about systems in this way, but [Phipps Executive Director] Richard Piacentini does."
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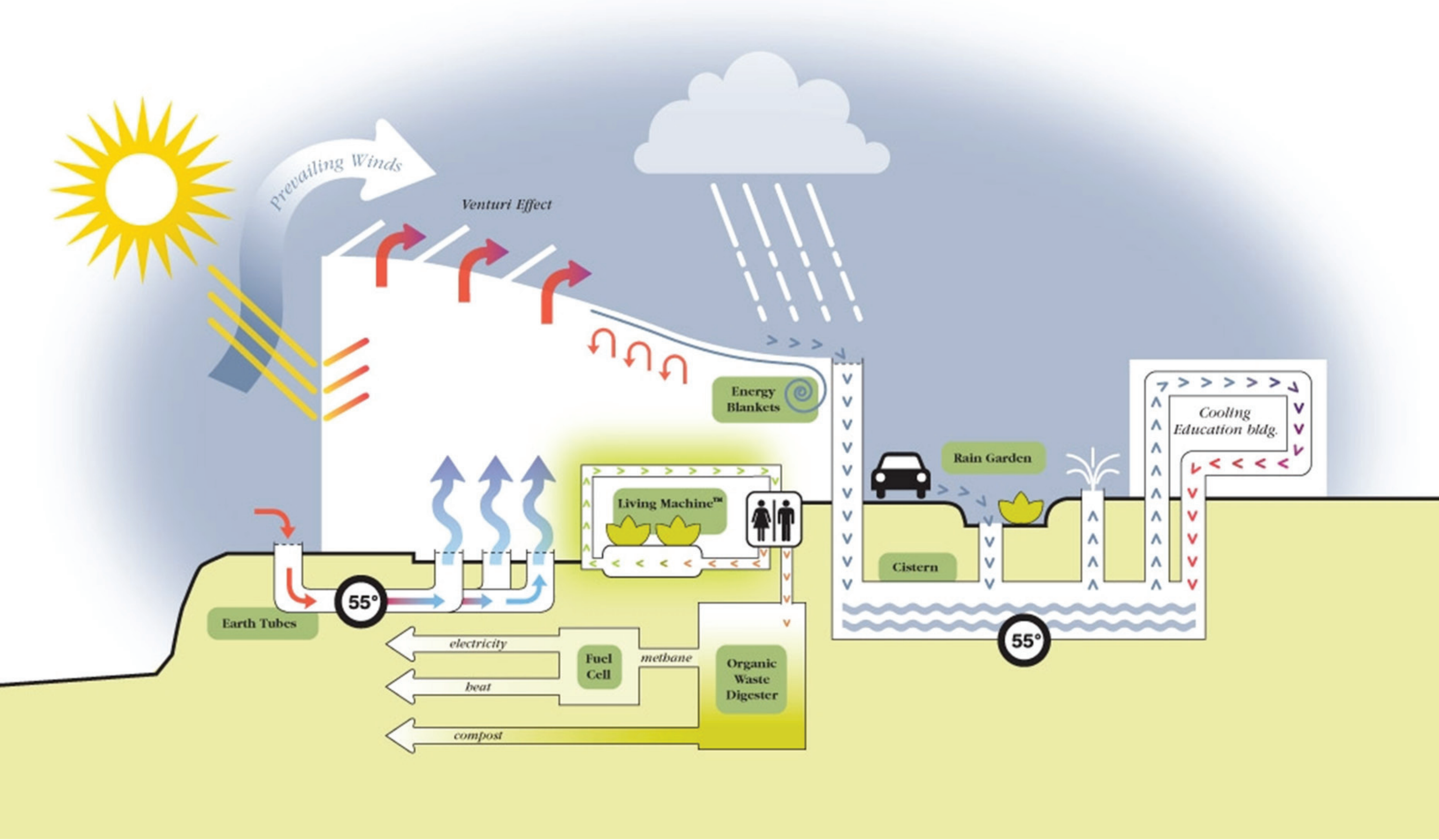
> *—Vivian Loftness, Carnegie Mellon University School of Architecture*



BRAINSTORMING

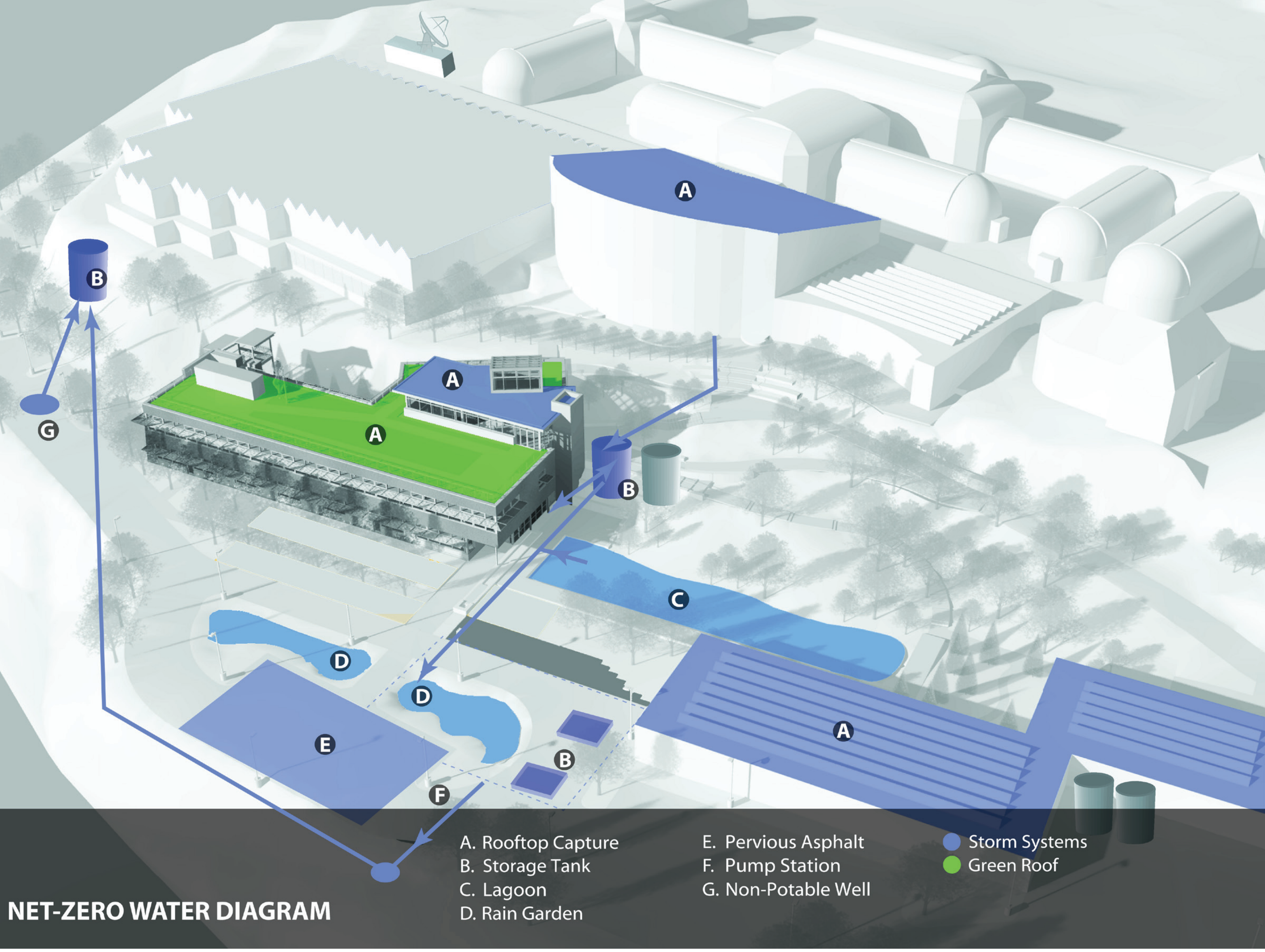
During initial planning charrettes, the CSL team considered various options as they aspired to net-zero water. They discussed installing a 200,000-gallon water cistern on the lower site to use as a thermal mass for heating and cooling, but this proved to be cost-prohibitive. They considered running organic waste from toilets and kitchens through a digester to produce methane, but calculations revealed that the site would not yield enough waste to make the plan economically feasible. (Even if they gathered organic café waste from nearby universities to run through a more substantial digester, the site would not accommodate equipment large enough to meet the necessary capacity). They pondered using a system similar to a Living Machine® as a way to treat wastewater but later decided that constructed wetlands would be a better fit for the site and help meet the project's goal of connecting the building to the landscape. They even thought about processing waste from the entire Phipps Conservatory and Botanical Gardens campus (beyond the boundaries of the CSL) through constructed wetlands on the site, but the necessary square footage was simply not available.

As the team moved forward, questions continued about how to make the best use of the substantial amount of rainwater that flowed down to the CSL from Phipps' upper campus and then exited the property via the combined stormwater-sewer discharge lines. Suddenly, it became clear that the CSL project had an opportunity to significantly decrease the overall site's overflow while also satisfying the Challenge.

Establishing a baseline, the team began to identify a solution by looking at how much stormwater they could realistically capture on site via rain gardens, underground tanks and constructed wetland lagoons. Their calculations revealed that a combined system was capable of holding back an entire seven-year storm event if properly designed. Only at the 10-year point would water overflow out of the combined system. Next, they figured out how to use the captured water for the building's various water needs.

DRAWING FROM THE CITY FOR POTABLE WATER

The Living Building Challenge allows municipal water to be delivered to a project for consumption purposes only if the local jurisdiction restricts onsite water treatment for potable use. The City of Pittsburgh, like many jurisdictions, requires a building to become its own water authority if it seeks to sup-

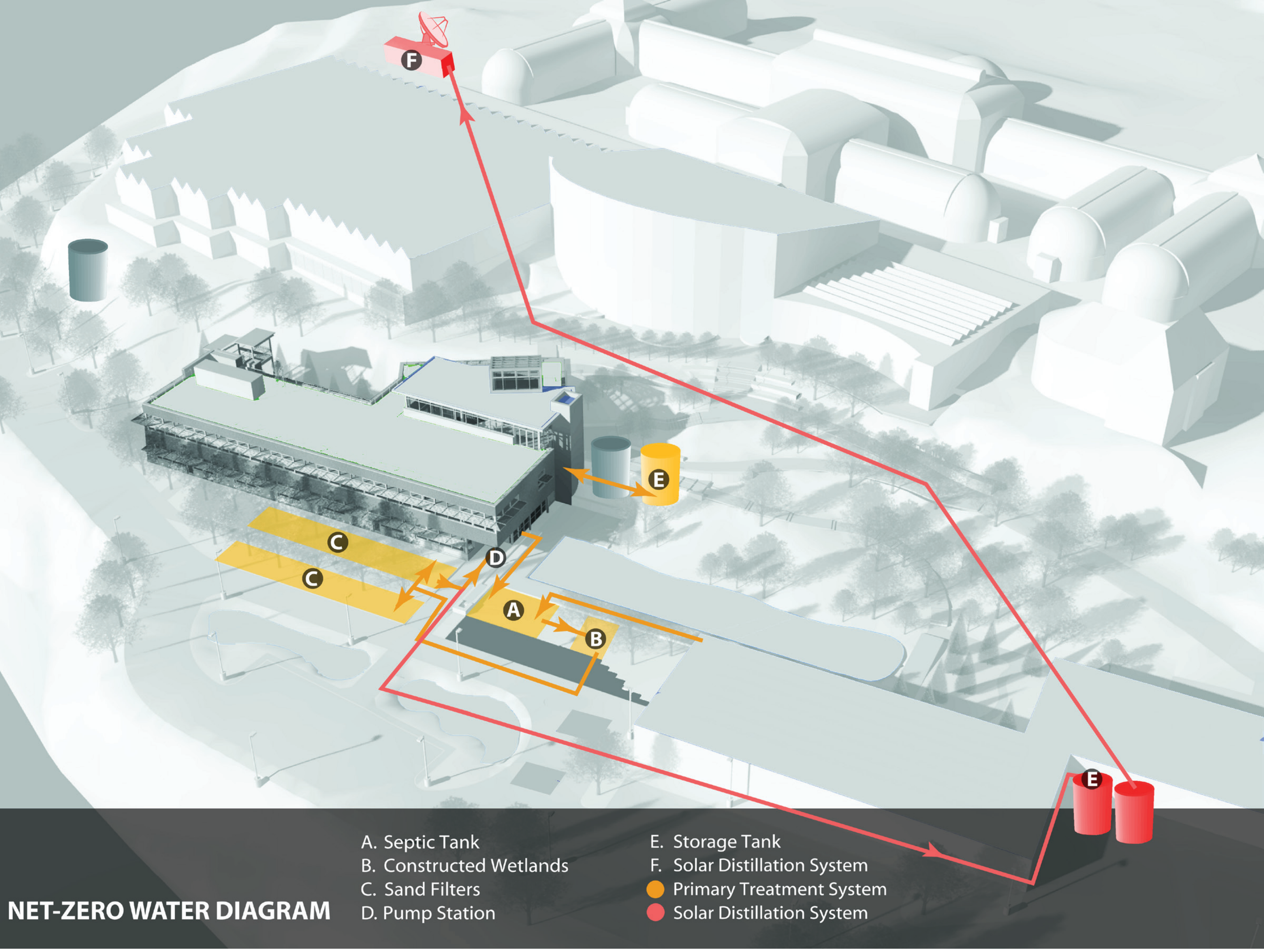


ply its own potable water. The Center for Sustainable Landscapes team opted to accept potable water into the site through municipal lines that feed the entire Phipps Conservatory and Botanical Gardens campus. When they looked at the project in its entirety, they felt that they would actually capture and clean far more water than they would ever extract from the municipal system, which would more than justify their draw from city sources and help meet the overall net-zero goal.

COLLECTING WHAT FALLS FROM THE SKY

At the heart of the CSL's water strategy is its multilayer stormwater and rainwater capture strategy. The systems are separated based on how water is re-used (for irrigation as opposed to sanitary purposes), but there is a certain level of redundancy among the systems that allows water to be pulled from one system to serve another if needed. Rain that gets re-used on the Phipps Conservatory and Botanical Gardens campus falls onto clean surfaces – glass rooftops, landscaped fields or healthy wetlands – before continuing its journey through the site's sophisticated water treatment system.

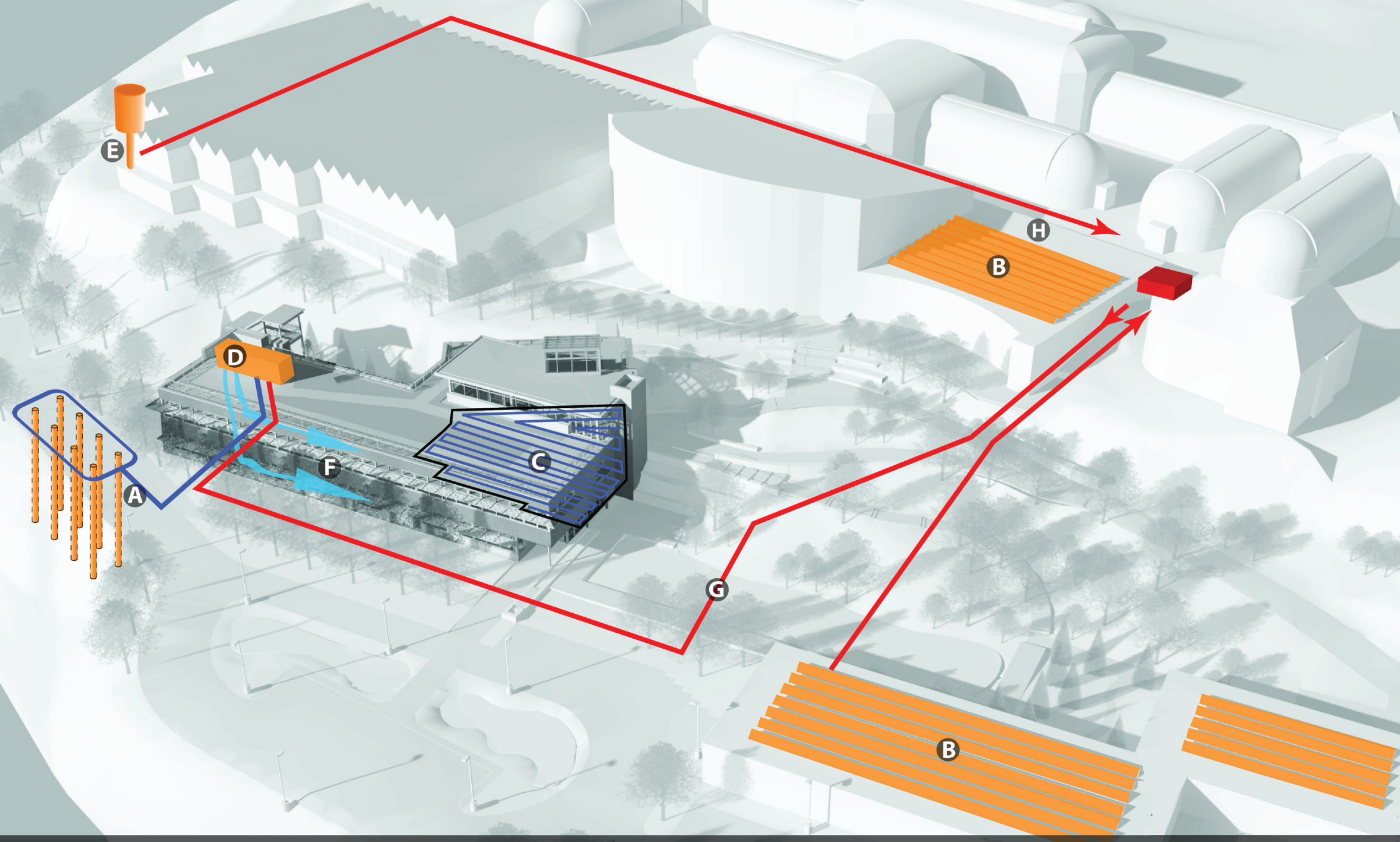
- The substantial rooftop space atop the Tropical Forest Conservatory is ideal for collecting the nearly 40 inches of average annual precipitation that hits Pittsburgh.
- Captured rainwater from the Conservatory roof flows into a 1700-gallon underground cistern that supplies the initial water for flushing toilets and for irrigation.
- The CSL's own third-floor roof provides another surface space where rainwater may be collected.
- The maintenance building roof (host to the photovoltaic solar arrays) also sends rainwater into the system.



- A lagoon captures overflow from the cistern and surface runoff from most of the site and from the adjacent roofs.
- The lagoon overflows into underground rain tanks covered with permeable groundcovers and part of the site access road. These stackable milk crate-style units are wrapped in a geotextile fabric to provide structure strong enough to accommodate vehicle traffic, while being porous enough to provide significant carrying capacity.
- The underground rain tanks are divided into two sections for a combined 80,000 gallons of capacity. Tanks capable of storing 64,000 gallons of water are lined so that the cleaner runoff from the site can be captured and used for irrigation. Another 16,000 gallons of storage tanks are unlined and designed to capture runoff from the road. In the summertime, when this water is relatively clean, it can also be channeled into the lined rain tanks and used for irrigation. In the winter, when there is a chance of contamination by road salts, the water can infiltrate into the ground.
- Sanitary water is cleaned on site with a constructed wetland and sand filters. After the water is cleaned, it is pumped to another 1700-gallon cistern, where it is used to flush the toilets.

"Before this, Phipps only used municipal supplies for their water needs. Now we have a large reservoir of water that we can re-purpose."

— Michael Takacs
Civil & Environmental Consultants, Inc.



NET-ZERO ENERGY DIAGRAM

A. Geothermal Wells
B. Photovoltaic Array
C. Hot Water Radiant Floor
D. Tri-Coil Rooftop Mechanical Unit
E. Wind Turbine
F. Under Floor Air Distribution
G. 100% CSL Electric Supply
H. Excess Power to Campus

IRRIGATION HELPS MEET NET-ZERO WATER IMPERATIVE

Water needed to irrigate the CSL's green roof and its interior plants requires the least amount of treatment. The system pulls greywater from one of the underground storage tanks, runs it past a UV filter to be cleaned (but not purified to potable standards), and delivers it to hose bibs throughout the site.

But as the project team designed the water strategy for the CSL, engineers had to take into consideration the fact that the site would collect more water than it would need for its own irrigation uses. So as they continued to calculate existing and projected water usage, they sought solutions that would balance what the CSL system would capture with what the building and landscape would use. And, because the Living Building Challenge restricts water from going back into the municipal storm system, they had to make sure that the excess water would infiltrate the ground rather than have it flow back into the sewer.

The original water strategy called for unlined underground storage tanks capable of collecting approximately 60,000 gallons of stormwater, which would then seep into the ground (rather than flow back through municipal pipes). Then two things happened. First, a new water engineer came to the project and determined that the original calculations were too low, and the project actually needed to add another 20,000 gallons of rainwater storage to meet the Challenge. Second, in the process of drilling the geothermal wells, the driller discovered that there was enough water underground to supply a well capable of producing 20,000 gallons of water per day.

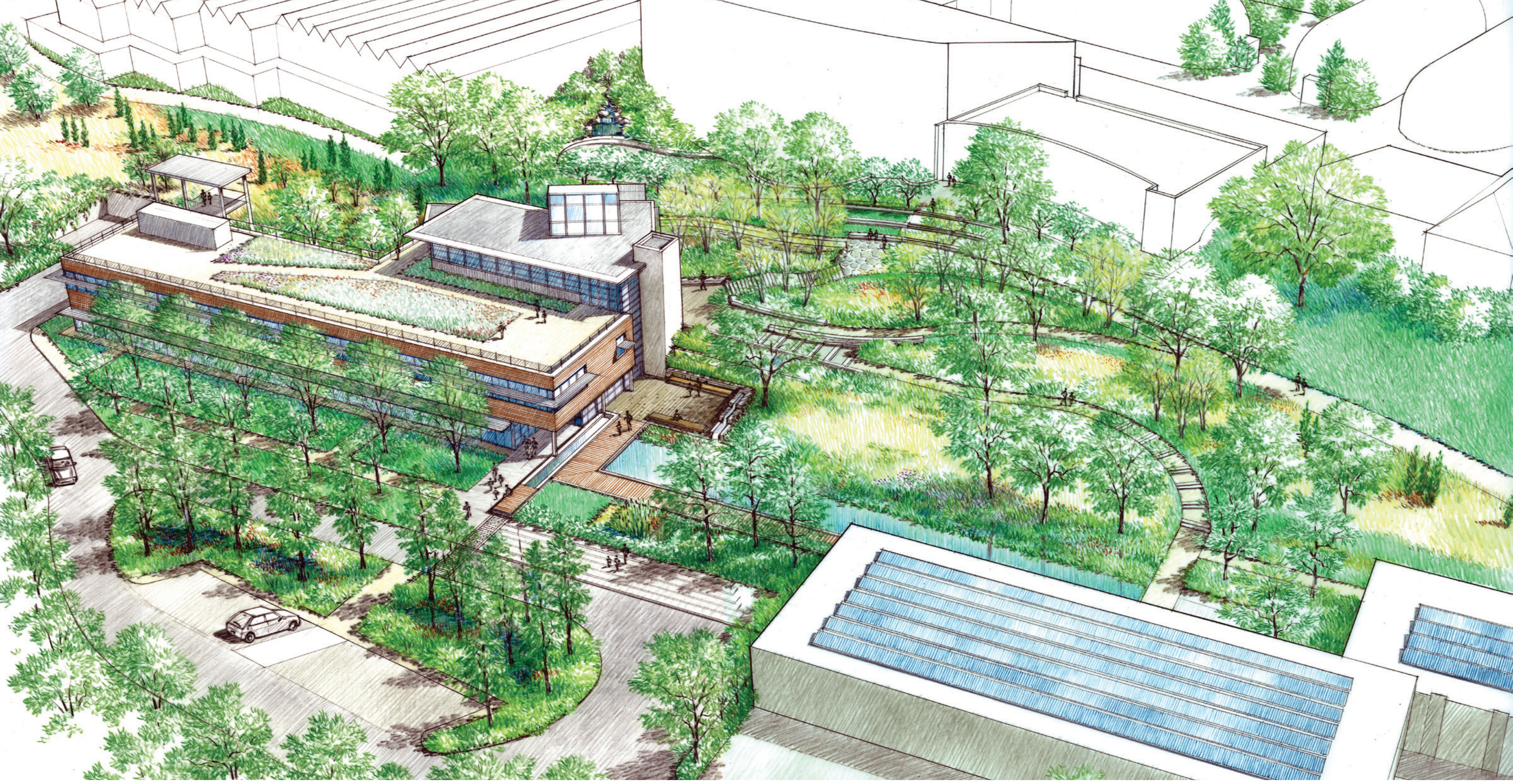
Then Richard V. Piacentini got an idea: Since Phipps Conservatory and Botanical Gardens uses between 20,000 and 24,000 gallons of water daily to water plants in the Conservatory, why not take water harvested at the CSL and use it for irrigation on the upper campus rather than let it seep into the ground? Simply capturing rainwater in the underground tanks would only offset a couple of months' worth

of irrigation, he thought, which would not be financially feasible. However, supplementing with a well would mean Phipps could offset all of the irrigation water with more than seven million gallons per year.

He approached the team with a request to add a 24,000-gallon cistern on the upper campus that could hold one day's worth of water – between 20,000 and 24,000 gallons – and line the underground rain tanks rather than let their contents seep into the ground. They could supplement the cistern on the upper campus with the contents of a well on the lower campus when the rain tanks were empty. Initially, the team raised concerns about the idea because the Challenge does not typically allow projects to use well water. Also, they worried that if the rain tanks were full at the time of a storm, the excess water would overflow into the sewer lines and the CSL would fall short of the Challenge's requirements.

Piacentini requested that the team calculate the rate at which the water stored underground would infiltrate into the ground. Their answer: approximately 20,000 gallons daily. So why not draw off that amount every day and use it for irrigation purposes on the upper campus? This way, the organization could use the water just as quickly as it could infiltrate, drawing down Phipps' overall water demand from the City of Pittsburgh. Using captured stormwater, combined with well water, would create a supplemental irrigation supply capable of delivering more than seven million gallons to the Conservatory annually. Wouldn't it make sense to "scale jump" if it meant reducing Phipps' annual municipal draw of potable water by such a vast quantity when treated greywater was perfectly suitable? So the team requested – and received – a variance from the International Living Future Institute (ILFI) to allow for water stored within the boundaries of the CSL site to be pumped to, and used in, the Conservatory – a solution that fits into the Challenge's scale-jumping protocol.

Ultimately, the ILFI and the CSL team agreed that



The Center for Sustainable Landscapes represents the third and final phase of an ambitious renovation and expansion plan at Phipps Conservatory and Botanical Gardens that will distinguish the campus as one of the world's greenest gardens.

what is appropriate for Pittsburgh might not be the same as what works in Houston, Seattle or any other part of the country. Rainfall varies, as do water use needs. The key is to define what net zero means for each distinct project, and then work to implement solutions to achieve specific goals. In the case of Phipps, the CSL is capable of harvesting far more water than it needs for the lower campus and pumping irrigation water to the upper campus (which falls outside of the Challenge project scope) helps offset the building's overall intake of municipal potable water. As calculated, the net use is zero or less.

USING WETLANDS TO TREAT BLACKWATER

The CSL's sanitary system carries water through a closed loop that begins and ends on site, drawing nothing from the municipal supply. Greywater, initially captured from the roof of Phipps Conservatory and Botanical Gardens' Tropical Forest Conservatory, is used to flush the toilets in the CSL and flows into a tank on the exterior grounds. Solids settle out and liquid effluent travels to one of two constructed wetland treatment cells. The wetlands' plants help uptake most of the nutrients in the liquid effluent, which then passes through a series of treatment sand filters before working its way into a pump tank that returns the water to a re-use holding tank. Here, the water is continually cycled through an ultraviolet filter until pumps draw the filtered greywater back up into the building, where it is used once again to flush toilets and the cycle begins anew.

In order to enhance the function of the wetlands, plant species were carefully chosen for their ability to thrive in nitrogen-rich environments. Those selected for the CSL site include a variety of grasses, reeds, bulrushes and other plants typically found in natural wetlands.

"From an architect's perspective on the design, we realized early on that with this tight site and lots of grade changes, constructed wetlands would be an appropriate solution for the project. It also made sense because it embodied the spirit of Phipps. It demonstrates how the landscape integrates into the building; how the building and the landscape become one singular machine."

—L. Christian Minnerly
The Design Alliance Architects

SURPLUS WATER FINDS A ROOFTOP HOME

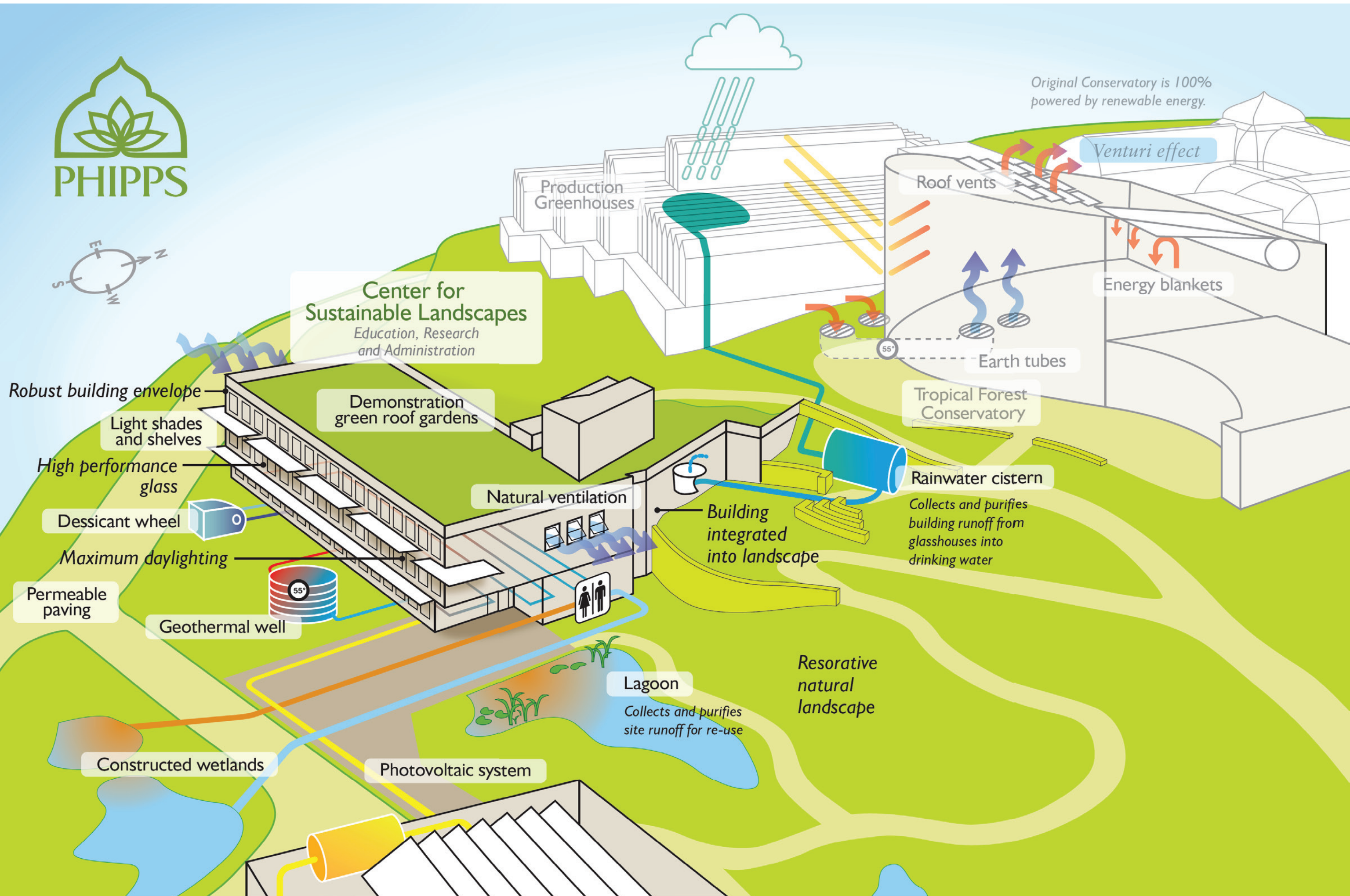
Once engineers ran the numbers for the full spectrum of water re-use strategies, it was clear that they were re-purposing nearly all of the water waste that was coming out of the Center for Sustainable Landscapes. But not every last drop. Every day, the system ended up with approximately 200 gallons of potential excess effluent water from the sanitary loop. The team considered disposing of it on site through a traditional infiltration process, but the soils were not conducive to such an approach and the Department of Environmental Protection denied the request. The team then explored the possibility of spray-applying it in the greenhouse, but that was not permitted either. Pushing it back into the municipal sewer would mean losing the water petal, so some solution had to be found. That is when Richard V. Piacentini heard about an innovative water distillation product that could help the CSL turn its extra sanitary water into greywater. Best of all, the product was created right in western Pennsylvania, just 60 miles away from Phipps Conservatory and Botanical Gardens.

Called the Epiphany Solar Water System, the product uses parabolic solar dishes lined with reflective coating to generate heat that powers multi-stage distillation units to create clean water. Originally designed to serve populations without direct or adequate access to clean drinking water, the Epiphany units can turn contaminated water into potable water using only the sun's energy.

The team agreed with Piacentini that the Epiphany units, which produce pharmaceutical-grade distilled water, would provide the ideal irrigation source for the Conservatory's delicate orchids, which do not respond well to the minerals found in the municipal supply. Now, 12 distilling units sit on the roof of the Production Greenhouses to serve such a purpose. (The team explored the possibility of keeping Epiphany units on the CSL site, but there was simply no room to accommodate them.)

On cloudy days when the units are not operating at full power, the excess effluent flows from the sanitary system to the two underground 12,000-gallon tanks adjacent to the restored Department of Public Works structures that had previously been used to store fuel. The tanks were tested for contaminants,

True to the nature of the Living Building Challenge, the various systems designed for the Center for Sustainable Landscapes work off of one another to achieve the project's performance goals, including net-zero water and energy.



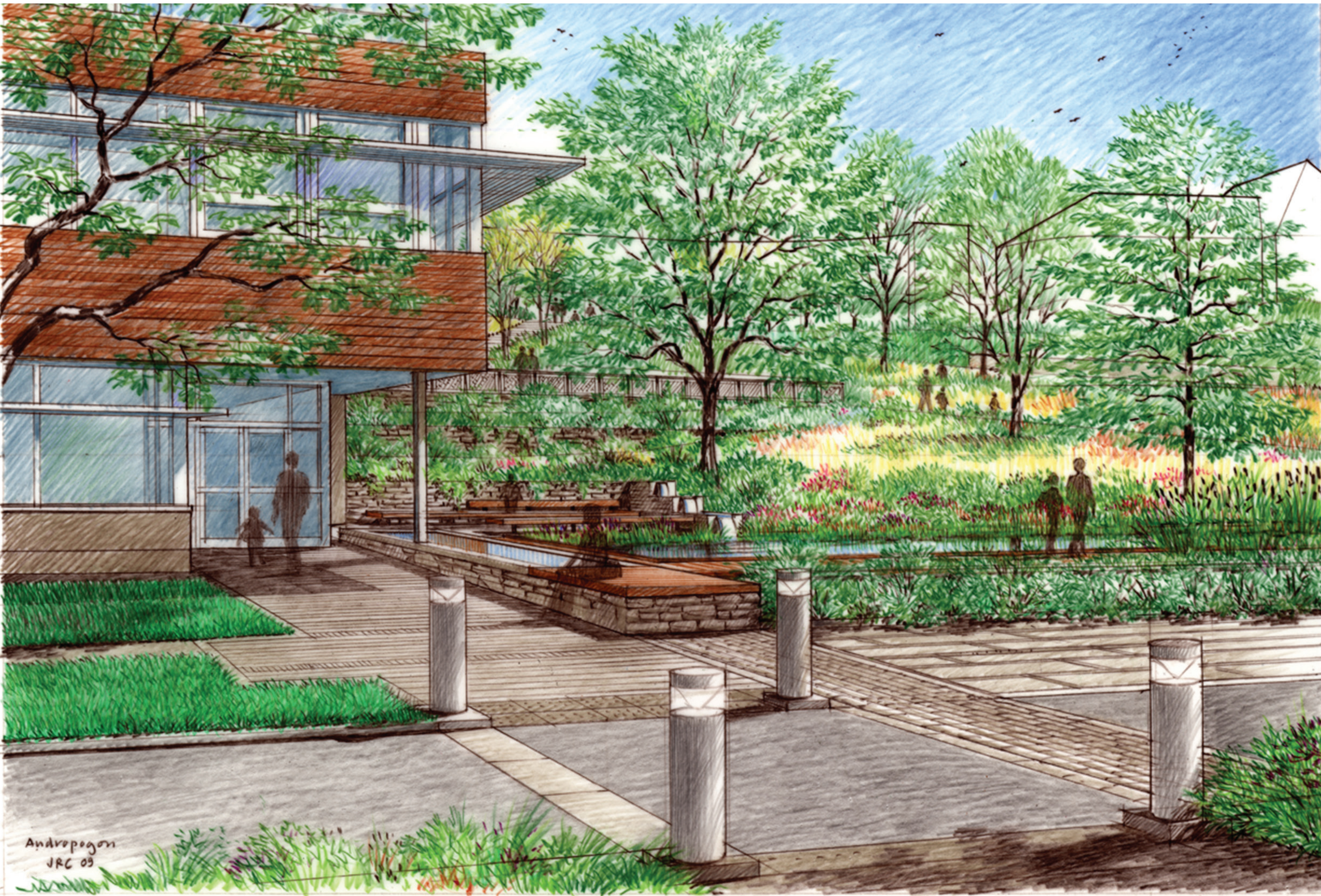
thoroughly cleaned and transferred from the City of Pittsburgh to Phipps. They now serve as temporary holding tanks for water that awaits the next sunny day, when it travels through the Epiphany system and on to the Orchid Room.

A WATER-FRIENDLY LANDSCAPE

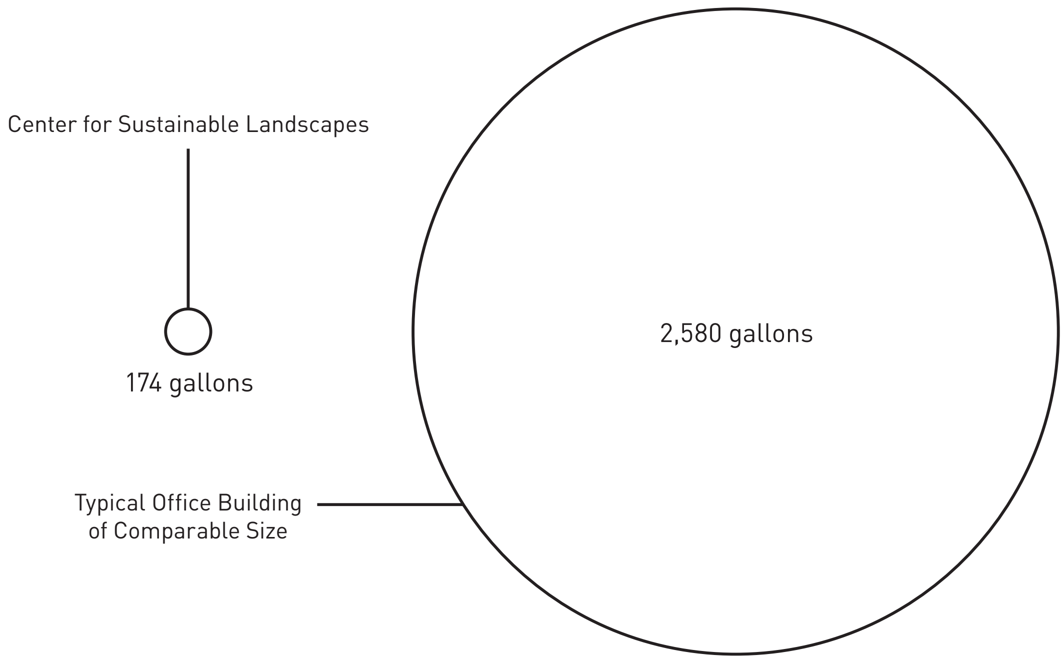
With the Center for Sustainable Landscapes water systems designed, it was important to determine which plant species and soil types would work best in the landscape while serving the water efficiency goal, enhancing the aesthetic impact of the site and furthering its educational mission. In this regard, plants and soils requiring less irrigation would be more sustainable. Still, the chosen species needed to be visually appealing to help draw visitors in, which meant that there needed to be a balance between hearty and delicate options. The Andropogon Associates landscaping team opted for a blend of deciduous, evergreen and understory trees, along with a variety of shrubs, vines, perennials, grasses and seed mixes.

"When you're considering landscapes that require constant life support, you have to make sure you're getting more out of them than just sustaining them. At a place like Phipps, it has to look good so the visiting public will think they're beautiful and want to come back to see them again. The more they return, the more they learn. So that may trump the requirement of having plants that use less water if it helps serve the mission."

— José Almiñana
Andropogon Associates



Expected Daily Water Consumption



THE WATER-ENERGY CONNECTION

The CSL's engineers were not only asked to create water-efficient systems but they were also charged with creating water-efficient systems that were as energy-efficient as possible. Their overall solutions to the project's site-specific water needs might have looked quite different had they not needed to keep the water systems' energy draws so low. For example, blackwater could have been processed with technology that takes less land volume and more energy while delivering the same re-usable water result. But to achieve the dual water and energy goals of the Living Building Challenge, systems needed to be more economical.

The only electric pumps not figured into the overall water balance are those used to move stormwater from the lower to the upper campus. Because the water is being repurposed for use beyond the CSL's boundaries, the power needed to deliver the necessary volume of water is exempt from the project's Challenge-specific net-zero energy calculation. The additional benefit of re-using the water for irrigation made enough sense for the International Living Future Institute to permit the extra energy usage required to power the larger pumps.

WORKING WITH THE CITY

Of all the Living Building Challenge Petals, water requires the greatest interaction with the municipality that would otherwise serve the project's utility needs. Various members of the CSL team interacted with the City of Pittsburgh and the Allegheny County Health Department to ensure that the project met local codes as well as Challenge requirements.

Since the CSL's multi-tiered waste water treatment system had never been implemented on any other project, there was no precedent with which the city or county inspectors could compare it. Instead, team members had to walk them through and familiarize them with the various processes as the project progressed, making design revisions along the way in order to satisfy code requirements. In this way, the CSL has helped inform municipal officials about alternative site-specific water treatment solutions that can help cut down on the wasteful "use-and-lose" processes that have been in place for so many years.

The CSL's lagoon system captures stormwater runoff from throughout the site and replicates the natural water treatment process that occurs in wetlands and marshes.

"One of the biggest hurdles was related to getting local officials to approve various systems in our project. Waste water treatment is a good example. At first, they balked, but the more we explained the process, the more agreeable they became. While they didn't approve everything we proposed, eventually we came up with a solution everyone could live with."

—Richard V. Piacentini, Phipps Conservatory and Botanical Gardens

THE BEAUTY IN THE BIG PICTURE

The Center for Sustainable Landscapes is home to numerous innovative and sustainable water systems, both inside and outside the building. However, it is the combination of these approaches that makes the project one of a kind from a water-efficiency standpoint.

While other buildings treat water using constructed wetlands and store stormwater on site, the CSL's design-engineering-construction team made individual solutions even better by tying them to one another. The result is a cohesive set of strategies that works most effectively when connected.

BRILLIANCE RISES TO THE SURFACE

Designing the CSL's overall water strategy was one of the project's most complex and time-intensive aspects, which was further complicated by several major direction shifts along the way. Deciding to pump stormwater to Phipps Conservatory and Botanical Gardens' upper campus required a substantial set of design changes after construction had begun, as did deciding to send up to 200 gallons of water per day to the rooftop solar distilleries. While each change led to a potential performance improve-

"All of us who have worked on this project have come to the same conclusion: The Living Building Challenge forces you to think in systems. You have these loosely related but overarching goals, and the Challenge forces you to think about how every action is connected to something else and has a consequence. Every action gives you the opportunity to connect the dots and achieve those goals."

—Richard V. Piacentini, Phipps Conservatory and Botanical Gardens

The plants and soils in the landscape surrounding the CSL were carefully chosen to support the water mission of the project while also achieving its Challenge-related beauty and inspiration imperatives. The mid-slope birch grove with a permeable paving walkway is shown in this artist's rendering.

KEY CSL TEAM MEMBERS

Owner
Phipps Conservatory and Botanical Gardens
Richard V. Piacentini, Executive Director

Lead Architect
L. Christian Minnerly, The Design Alliance

Landscape Design
José Almiñana, Andropogon Associates

Civil and Water Engineering
Michael Takacs, Civil & Environmental Consultants

MEP Engineering
Alan Traugott, CJL Engineering

LEED and Living Building Challenge Management
Marc Mondor, evolveEA

Pre-Construction Management
Massaro Corporation

Charrette Facilitation; Energy, Daylight and Materials Consulting
John Boecker, 7group,LLC

General Contractor
Turner Construction

Academic Partners
Khee Poh Lam, Carnegie Mellon University Center for Building Performance and Diagnostics
Vivian Loftness, Carnegie Mellon University School of Architecture
Melissa Bilec, Univ. of Pittsburgh Mascaro Center for Sustainable Innovation

ment, it still required the team to stop, redesign and reconfigure before proceeding in the new direction.

Despite these challenges, the CSL's sophisticated water strategy will now benefit countless future projects and professionals by showing what is possible. Even if no other building incorporates the CSL's entire collection of solutions, elements of the overall approach may be used to achieve vastly improved levels of water performance.

MARY ADAM THOMAS collaborated with Jason F. McLennan on his most recent book, *Zugunruhe*. She is also the collaborative author of *The Web-Savvy Patient*. Mary lives in the Seattle area, where she provides writing services through Thomas Communications.

Building in Bloom: The Making of the Center for Sustainable Landscapes at Phipps Conservatory and Botanical Gardens
by Mary Adam Thomas is the first in a series of publications about leading-edge Living Building projects throughout North America that are connected to the International Living Future Institute's Living Building Challenge.